Dedicated Silicon Detectors for Imaging and Spectroscopy at Synchrotron Light Sources and X-ray Free Electron Lasers

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In the field of X-ray Imaging and spectroscopy at synchrotron and free electron light sources a broad spectrum of properties must be addressed

- High spatial resolution: from 2 µm up to several hundred µm
- A large number of pixels from 10^3 up to 10^7
- High frame rate: from 10 Hz up to several MHz
- High dynamic range: from single photon detection up to 10^5 photons per pixel
- Low electronic noise in the case of X-ray spectroscopy
- A high quantum efficiency for X-rays from tens of eV up to 100 keV
- Radiation hardness, i.e. long term stability
- and many other properties

There is not just one detector which can cover the entire list of properties listed above with one detector system. For example, a very high dynamic range for recording diffraction pattern conflicts with a very low noise requirement for high spectral resolution for low energy X-rays. A very high frame rate conflicts with small pixel sizes and low noise. High radiation tolerance is in conflict with a high quantum efficiency at very low X-ray energies etc. We will describe four different systems for dedicated measurements combining a subset of the above non-complete list of desired properties:

system 1: Highest position resolution (2 µm), high frame rate (10.000 fps) , excellent energy resolution (Fano limited, 3 el. noise (rms)) but limited dynamic range (400.000 signal electrons)

system 2: High quantum efficiency up to 100 keV (90%), but limited low energy response at 1 keV at moderate readout rate (1.000 fps)

system 3: High speed readout (10^6 fps), large format (MPixel), high dynamic range (10^4 photons), but increased electronic noise and moderate spatial resolution (200 µm)

system 4: Medium frame rate (500 fps), large format (1 MPixel), good spectroscopy, medium dynamic range (1.000 X-rays of 10 keV)